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Copper Diamond Composite Substrates for Electronic Components*

John Kerns, Dan Makowiecki, and Nick Colella
Lawrence Livermore National Laboratory
and Howard Davidson, Sun Microsystems

Abstract

The application of high power density electronic components such as fast microprocessors and RF power amplifiers is often limited by an inability to maintain the device junctions below their maximum rated operating temperature. The junction temperature rise is determined by the thermal resistance from junction to the ambient thermal environment. Two of the largest contributions of this thermal resistance are the die attach interface and the package base. A decrease in these resistances can allow increased component packing density in MCMs, enable the use of higher performance circuit components, and improve reliability.

The substrate for a multichip module or device package is the primary thermal link between the junctions and the heat sink. Present high power multichip module and package designs use substrate materials such as silicon nitride or copper tungsten that have thermal conductivity in the range of 200 W/mK. We have developed a copper-diamond composite thermal conductivity of 420 W/mK, better than copper, and an adjustable coefficient of thermal expansion, nominally 6 ppm/C, compatible with silicon and gallium arsenide. Because of the match coefficient of thermal expansion, it is possible to use low thermal resistance hard die attach methods.

Dymalloy is composite material made using micron size Type I diamond powder that has a published thermal conductivity of 600 to 1000 W/mK in a metal matrix that has a thermal conductivity of 350 W/mK. The region of chemical bonding between the matrix material and diamond is limited to approximately 100 Å to maintain a high effective thermal conductivity for the composite. The material may be fabricated in near net shapes.

Besides having exceptional thermal properties, the mechanical properties of this material also make it an attractive candidate as an electronic component substrate material.

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